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Addendum to a PDA-based Backup System for Generating Marine Corps Artillery Meteorological Messages

by Terry C. Jameson and David Sauter

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NOTICES

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U.S. Army Research Laboratory

Computational and Information Sciences Directorate

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14. ABSTRACT
A personal digital assistant (PDA) based application has been developed as a backup system to allow the computation of artillery meteorological messages (see ARL-TN-244 for a discussion of meteorological messages). An inherent part of the message creation is the availability of upper atmospheric meteorological data, which is either extrapolated from a surface observation or, in the case of wind vectors, computed via the visual tracking of a pilot balloon (PIBAL). However, in the event of clouds, PIBAL failure, or even the loss of visual contact with the PIBAL, it is possible that insufficient data is available to compute the upper atmospheric wind vectors. In these situations, upper atmospheric climatological data can be used to augment the PIBAL data (if any) to create a (hopefully) more representative meteorological message(s). This addendum details the algorithms and logic used to incorporate the climatological data in the event there is insufficient PIBAL data.

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Summary

This is an addendum to a previously published 2005 technical note by Terry C. Jameson and David Sauter, entitled: "A PDA-based Backup System for Generating Marine Corps Artillery Meteorological Messages," ARL-TN-244, U.S. Army Research Laboratory, White Sands Missile Range, NM 88002. The note documented a personal digital assistant (PDA) based application that allowed for the computation of artillery meteorological (Met) messages from raw user-entered site and Met information. This addendum documents the logic incorporated in the inclusion of upper atmospheric climatological data in the event of missing or incomplete user data. It also documents the software functions available, separate from the PDA application, as a dynamic link library (dll).

1. Introduction

The Fleet Numerical Meteorology and Oceanography (FNMOC) (*1*) Detachment, in Asheville, NC, has made available a CD with global Upper Air Gridded Climatology (UAGC). This UAGC data set describes the atmosphere for each month of the year represented on a 2.5° global grid at 15 standard atmospheric pressure levels. Mean and standard deviation values are included for sea level pressure, wind speed, air temperature, dew point, height, and density. For a more complete discussion of the data set, see the UAGC Version 1.1 documentation (*1*). The period of coverage for the data was 1980 through 1995 and the source of the data set was the European Center for Medium Range Weather Forecasting (ECMWF) gridded analyses from 0000Z and 1200Z (where Z represents Greenwich Mean Time). Coverage includes the entire globe, although for this implementation, only the Southwest Asia (SWA) domain (defined by a SW corner of lat. 27.5° N., long. 37.5° E., and a NE corner of lat. 40.0° N., long. 75° E.) is utilized. This subset of data has been hosted on the personal digital assistant (PDA) as a set of 12 monthly American Standard Code for Information Interchange (ASCII) text files, which are then accessed by the artillery Met application. Simple functions retrieve the appropriate climatological data for the grid location nearest the user location and for the month specified. The following sections discuss in additional detail the logic for incorporating (or not) the upper air climatological values. It assumes that the reader is familiar with the terminology related to meteorological messages and artillery meteorology. If not, the reader is referred to the previously mentioned report with respect to this addendum.

2. Wind Steadiness Factor

The UAGC database contains wind information in east-west, north-south vector component, mean vector wind, and mean scalar wind forms. An assessment of the "steadiness" of these climatological wind records was desired, such that the data would not be used in the PDA Computer Met Messages (METCMs) or Ballistic Met Messages (METBs) if they were too highly variable in nature. A measure of wind variability, called the "Steadiness Factor" (SF) was employed for this purpose (*2*). Simply stated, the SF is the ratio of the *magnitude* of the mean vector wind to the mean scalar wind. Thus, the SF can vary from 0.0 to 1.0, with *lower* values indicating *more* variability, which would be less desirable for inclusion in the METCMs and METBs. For example, if the mean vector wind magnitude is 2.6 m/s and the mean scalar wind is 9.8 m/s, the ratio of 2.6/9.8 = 0.27 is the wind SF for that particular data record.

Initially, it was not known what type of SF values (as a function of month and mandatory pressure level) typically occurred in the overall UAGC database. In order to determine an appropriate SF, below which a particular data record would not be used in the METCM, a Matrix Laboratory (MATLAB) programming language code was written to compute and plot these values within the UAGC database. This program, called *sf_eval.m*, defines the boundaries of an area of interest (AOI) and calculates the SF values for each month, each mandatory pressure level, and each 2.5° latitude and longitude grid point within those boundaries. The AOI used in the MATLAB program was bounded by 40.0° N latitude and 27.5° N latitude, and 75.0° E longitude and 37.5° E longitude (encompassing the SWA region). A statistical median value* is calculated using all grid points in the AOI, by month and mandatory pressure level.

Figure 1 is a plot of the median SF values that were calculated by *sf_eval.m*. Overall, the least variability in winds (highest SF values) occurred at the highest level of the atmosphere that was included in this study, 300 millibars (mb). Except for a slight dip in July and August, the SF at 300 mb remains near 0.90. The line plots show that, moving to lower levels of the atmosphere (400 mb, 500 mb, down to 700 mb), the SF values progressively decrease. That tendency continues for the lowest two levels (850 mb and 1,000 mb) as well. However, for these two levels, the SF values are lowest during the winter months, which is opposite to the trend higher up in the atmosphere. This observation could be due to the fact that nearer the surface during the winter months, frontal passages and other significant wind shifts frequently occur, which would tend to increase the variability and thus decrease the SF value.

In reality, the UAGC winds at 850 mb and 1000 mb would seldom, if ever, be used to generate METCMs by the PDA Met system. This is because the PIBAL wind observations would almost always be available at those near-surface levels. As figure 1 indicates, the median SF values at 500 mb, 400 mb and 300 mb never drop below 0.70, and only during the summer months at 700 mb. Consequently, a SF threshold of 0.70 was adopted, below which a particular wind record would not be used to construct the METCM. Looking at this SF threshold in a different manner, the 0.70 level equates to the wind direction being within a 90° sector approximately two-thirds of the time throughout any given month.

* Half the grid point SFs were greater than the median and half were less.

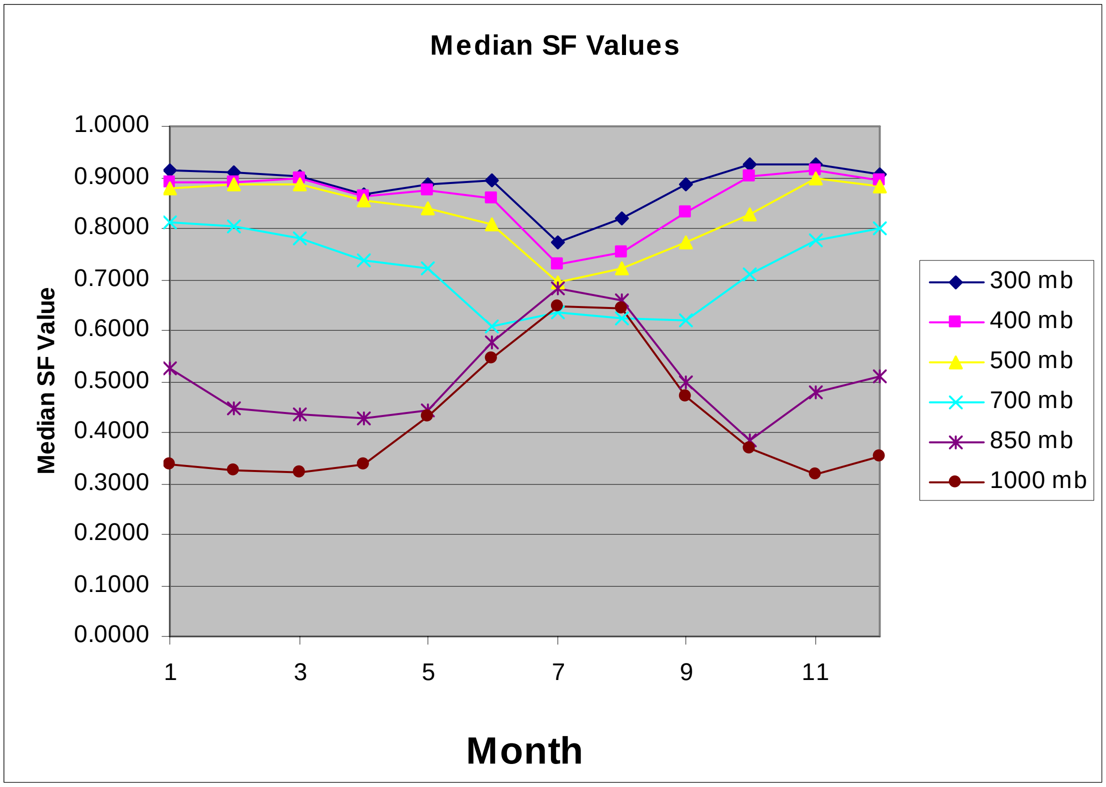

Figure 1. Plot of median SF values by mandatory pressure levels and month.

3. UAGC Implementation

Before incorporating the UAGC data into a Met message that has an insufficient set of PIBAL readings, a validation is done. This validation consists of three individual steps as described below:

1. The PIBAL derived wind speed for the last available Met message zone and the climatological wind speed interpolated to the next highest zone must be less than 10 kts (per 1,000 meters of height difference between the zones). As the climatological data is only available at 15 standard pressure levels, the Climo wind is (linearly) interpolated to the specific Met message zone heights.

2. The wind direction difference between the adjacent zones must be less than 90°.

3. The wind vector steadiness factor for the zone based on the climatology (as discussed in section 2 above) must be greater than 0.7.

If any of the above criteria is not met, the climatological data will not be used and the wind vector from the previous zone (from the measured PIBAL data) will be used instead. In this case, the validation check will continue for each next higher zone, with the climatological data from the next highest zone being compared to the next lower level. If at some zone, the three criteria above are met, the climatological data will then be used for all remaining higher zones.

Also, before the UAGC data is incorporated into either of the Met messages, the pop-up dialog box shown in figure 2 is displayed. If the user responds "No", a Met message is created containing only those lines that can be computed by the measured PIBAL data.

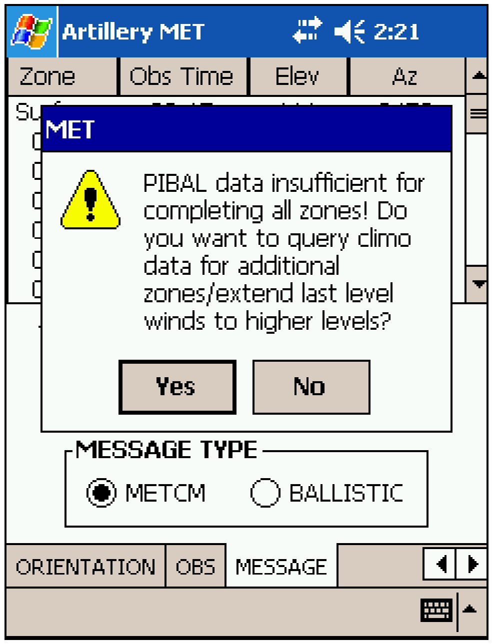

Figure 2. Pop-up dialog box displayed to user.

For parameters other than the wind vector, the surface observations are used and extrapolated using the meteorological principles outlined in the technical note. If no PIBAL line entries are made, the wind vectors for the entire METCM or METB message are derived from the UAGC data.

In certain instances, there may be missing UAGC data for one or more levels and parameters. In this event, instead of displaying the derived or interpolated Met message based on that parameter, "****" text will be displayed. If the user selects a geographic region outside of the SW Asia domain a message to this effect will be displayed.

4. Dynamic Link Library Functions

In order to facilitate the use of the UAGC data by applications other than the artillery Met software, the functions used to access and/or interpolate the data are also made available as a C++ dynamic link library (dll) on the PDA. Other applications can link to this library and then use one or more of the included functions. Each of these functions (in **bold**) is documented below and indicates the function type, the input and output parameters, and a brief description of the purpose:

float *__MeanParamP__(short month, float lat, float lon, short paramID, short pressureLevel)
==

<Name>
MeanParamP()

<*Description*>
Retrieves the mean value of the user specified parameter for the gridpoint nearest the passed lat and lon for the requested month and standard pressure level.

<*Input*>
short: month - 1-12
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
short: paramID - coded parameter ID where
0 = wind vector
1 = air temperature
2 = dew point
3 = density
short: pressureLevel - standard pressure level where
1 = surface
2 = 1000 mb
3 = 850 mb
4 = 700 mb
5 = 500 mb
6 = 400 mb
7 = 300 mb
8 = 250 mb
9 = 200 mb
10 = 150 mb
11 = 100 mb
12 =   70 mb
13 =   50 mb
14 =   30 mb
15 =   10 mb

<*Return*>
float paramVals[3] - Float array containing the parameter values, per below:
paramID = 0: Mean wind direction (deg), mean scalar wind speed (meters per sec) & steadiness factor.
paramID = 1: Air temperature (deg C), standard deviation, -999.9
paramID = 2: Dew point (deg C), standard deviation, -999.9
paramID = 3: Atmospheric density (kg/m3), standard deviation, -999.9
paramID = 4: Height (meters) of pressure level, standard deviation, -999.9

float ***MeanParamZ**(short month, float lat, float lon, short paramID, int Z)
===

<Name>
MeanParamZ()
<Description>
Retrieves the mean value of the user specified parameter for the gridpoint nearest the passed lat and lon for the requested month and height. A simple linear interpolation schema is used in the vertical. This is justified over a more complex schema such as a cubic spline as the SW Asia monthly mean values consist of line segments with little slope variation between each other, with the exception of the tropopause, which is quite a bit higher than the levels that will be used for METB and METCM messages.
<Input>
short: month - 1-12
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
short: paramID - coded parameter ID where
0 = wind vector
1 = air temperature
2 = dew point
3 = density
4 = pressure
short: Z - height above mean sea level, meters (0-30,000)
<Return>
float paramVals[3] - Float array containing the parameter values, per below:
paramID = 0: Mean wind direction (deg), mean scalar wind speed (meters per sec) & wind steadiness factor. Value of -777 if user requested height is > top height of climo data (~100,000 ft).
paramID = 1: Air temperature (deg C), standard deviation, -999.9
paramID = 2: Dew point (deg C), standard deviation, -999.9
paramID = 3: Atmospheric density (kg/m3), standard deviation, -999.9
paramID = 4: Atmospheric pressure (millibars), standard deviation, -999.9

float2D **metCM**(short month, float lat, float lon, int elevation)
==

<*Name*>
metCM()
<*Description*>
Computes the data for levels of a METCM based on the upper air climo values.
<*Input*>
short: month - month (1-12) for message computation
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
int: elevation - station elevation above sea level, meters
<*Return*>
2D Float array of relevant values:
First index: level (0-27)
Second index: meteorological/misc parameter value, if first index = 0, then for second index value of:

0: latitude, decimal degrees (N positive)
1: longitude, decimal degrees (E positive)
2: surface elevation, tens of meters
3: surface pressure (millibars)

If the first index >0, then for second index value of:

0: wind direction (10's of mils)
1: wind speed (knots)
2: temperature (tenths of degrees Kelvin)
3: pressure (millibars)

float2D **metB**(short month, float lat, float lon, int elevation)
==

<*Name*>

metB()

<*Description*>

Computes the data for levels of a METB based on the upper air climo values.

<*Input*>

short: month - month (1-12) for message computation
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
int: elevation - station height above sea level, meters

<*Return*>

2D Float array of relevant values:
First index: level (0-16)
Second index: meteorological/misc parameter value, if first index = 0, then for second index value of:

0: latitude, decimal degrees (N positive)
1: longitude, decimal degrees (E positive)
2: surface elevation, tens of meters
3: surface pressure, percent of standard atmosphere value, multiplied by 10. If result >= 1000, then subtract 1000 from the result.

If the first index >0, then for second index value of:

0: wind direction (10's of mils)
1: wind speed (knots)
2: temperature, percent of standard atmosphere value, multiplied by 10. If result >= 1000, then subtract 1000 from the result.
3: density, percent of standard atmosphere value, multiplied by 10. If result >= 1000, then subtract 1000 from the result.

float ***T_P_Dens_SA**(int z)
===================

<*Name*>
T_P_Dens_SA()
<*Description*>
Computes the standard atmosphere temperature, pressure and density given an altitude.
<*Input*>
int: z - altitude above sea level, meters
<*Return*>
Float array of relevant values, for index of:
0 = temperature (deg K)
1 = pressure (millibars)
2 = density (kg/m3)

int **GetElevation**(float lat, float lon)
=========================

<*Name*>
GetElevation()
<*Description*>
Finds the surface elevation (meters) for the grid point nearest the passed lat and lon values.
<*Input*>
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
<*Return*>
int: Surface elevation in meters.

float **GetSfcPressure**(short month, float lat, float lon)
=====================================

<*Name*>
GetSfcPressure()
<*Description*>
Retrieves the mean surface pressure (mb) for the passed month at the gridpoint nearest the passed lat and lon.
<*Input*>
short: month - 1-12
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positive)
<*Return*>
float - Surface pressure in millibars.

float ***GetMSLParams**(short month, float lat, float lon)
==

<*Name*>
GetMSLParams()
<*Description*>
Retrieves the mean value of the wind vector, air temperature, dew point and pressure for the
gridpoint nearest the passed lat and lon for the requested month at mean sea level (MSL) elevation (0 meters). NOTE: The actual station elevation may be greater than 0 meters, however, the model that was used to produce the course grid values does not include terrain elevation data. It is the responsibility of the user to determine whether or not any of the data returned is valid for their site! The GetElevation function may be called to determine the actual elevation for the gridpoint nearest the user requested lat and lon.
<*Input*>
short: month - 1-12
float: lat - latitude in decimal degrees (N positive)
float: lon - longitude in decimal degrees (E positiv)
<*Return*>
float paramVals[5] - Float array containing the parameter values, per below:
[0] : Mean wind direction (deg)
[1] : Mean scalar wind speed (meters per sec)
[2] : Mean air temperature (deg C)
[3] : Mean dew point (deg C)
[4] : Mean air pressure (mb)
[5] : Mean air density (kg/m3)

float **GetVirtualTemp**(float Ta, float Td, float Pr)
======================================

<*Name*>
GetVirtualTemp()
<*Description*>
Computes the virtual temperature as a function of the dry bulb, dew point and pressure.
<*Input*>
float: Ta - air temperature (deg C)
float: Td - dew point (deg C)
float: Pr - pressure (mb)
<*Return*>
float: Virtual temperature (degrees Kelvin)

References

1. *Data Base Description For Upper Air Gridded Climatology* (UAGC) Version 1.1, OAML-DBD-47A; Fleet Numerical Meteorology and Oceanography Detachment: Asheville, NC, March 1996. (UNCLASSIFIED)

2. Singer, I.A. Steadiness of the Wind. *Journal of Applied Meteorology* 1967 (6), 1033–1038. (UNCLASSIFIED)

Acronyms and Abbreviations

ASCII	American Standard Code for Information Interchange
AOI	area of interest
dll	dynamic link library
ECMWF	European Center for Medium Range Weather Forecasting
FNMOC	Fleet Numerical Meteorology and Oceanography
MATLAB	Matrix Laboratory
Mbs	millibars
Met	meteorological
METB	Ballistic Met Message
METCM	Computer Met Message
MSL	mean sea level
PDA	personal digital assistant
PIBAL	pilot balloon
SF	Steadiness Factor
SWA	Southwest Asia
UAGC	Upper Air Gridded Climatology

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